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Research Article

Magnetic Sphincter Augmentation vs Fundoplication for GERD: A Comparative Review of Surgical Outcomes

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Abstract

Gastroesophageal reflux disease (GERD) is a widespread condition, and a significant proportion of patients experience incomplete symptom control despite proton pump inhibitor (PPI) therapy. Laparoscopic Nissen fundoplication (LNF), the traditional surgical treatment for refractory GERD, provides durable reflux control but is associated with anatomical disruption and side effects such as dysphagia, gas-bloat syndrome, and impaired ability to belch or vomit. Magnetic sphincter augmentation (MSA) with the Linx™ Reflux Management System has emerged as a less invasive alternative that preserves esophageal physiology. This review summarizes recent evidence on Linx implantation, including surgical technique, indications, contraindications, and outcomes relative to LNF. Current data show that MSA achieves comparable symptom relief with fewer postoperative complications and better preservation of normal gastrointestinal function. Long-term follow-up also demonstrates high device durability and a low rate of serious adverse events. In light of these findings, Linx should be regarded as a first-line surgical option for appropriately selected patients with GERD.

Keywords: Gastroesophageal Reflux Disease (GERD); Magnetic Sphincter Augmentation (MSA); Linx Reflux Management System; Nissen Fundoplication; Antireflux Surgery

Background

Gastroesophageal reflux disease (GERD) is a chronic condition marked by the retrograde flow of stomach contents into the esophagus, resulting in symptoms such as heartburn, regurgitation, dysphagia, and non-cardiac chest pain. Extraesophageal manifestations—including chronic cough, hoarseness, and asthma-like symptoms—are also well documented, complicating both diagnosis and management [1]. Globally, GERD prevalence has been steadily rising, now affecting nearly 20% of the adult population in Western countries [2].

Pharmacological therapies remain the cornerstone of initial GERD management. Proton pump inhibitors (PPIs) and histamine-2 receptor antagonists (H2RAs) reduce gastric acid secretion and promote mucosal healing. However, between 30–40% of patients experience only partial relief or complete non-response to once-daily PPI therapy, often due to mechanisms such as transient lower esophageal sphincter relaxations (TLESRs), bile reflux, or visceral hypersensitivity [3,4]. These refractory cases pose a clinical challenge, and in recent years there has been growing concern about the long-term safety profile of PPIs.

Emerging data from large cohort and case-control studies have linked chronic PPI use to increased risks of chronic kidney disease, community-acquired pneumonia, micronutrient deficiencies (e.g., magnesium and B12), and gastrointestinal infections including Clostridioides difficile [5,6]. These findings have motivated some patients and clinicians to consider procedural or surgical interventions earlier in the treatment algorithm.

Historically, surgical management for refractory GERD has centered on laparoscopic Nissen fundoplication (LNF), which involves wrapping the gastric fundus around the distal esophagus to reinforce lower esophageal sphincter (LES) function. While effective—with symptom resolution rates above 85% at 10-year follow-up—this technique is technically demanding and can lead to side effects such as dysphagia, gas-bloat syndrome, and inability to belch or vomit [7]. These complications have contributed to patient hesitancy and the declining rate of antireflux surgery in the United States and Europe [8].

In response, magnetic sphincter augmentation (MSA) with the Linx™ Reflux Management System has gained traction as a minimally invasive alternative. Comprising a ring of titanium beads with magnetic cores, the Linx device augments LES function by providing dynamic resistance to reflux while preserving the physiological ability to swallow, belch, and vomit [9]. The laparoscopic implantation procedure avoids the anatomic disruption inherent in fundoplication and is reversible, making it an attractive option for select patients.

Recent studies and systematic reviews published since 2019 suggest that MSA provides comparable control of GERD symptoms to fundoplication, with lower rates of bloating and higher rates of preserved belching and vomiting. Moreover, the safety profile of the Linx device has been validated in long-term follow-up studies, with low erosion and explantation rates [10,11].

Given the rising burden of refractory GERD, patient aversion to traditional surgery, and concerns about long-term pharmacologic therapy, MSA has emerged as a viable, evidence-based alternative to fundoplication in appropriately selected patients [12].

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Methods

A focused literature review was conducted using PubMed and Google Scholar to compare MSA with the Linx™ Reflux Management System to LNF in the treatment of GERD. Preference was given to peer-reviewed articles published within the last five years (2019–2025) to reflect current clinical practices and outcomes.

Search terms included "Linx," "magnetic sphincter augmentation," "Nissen fundoplication," and "GERD." Studies were selected based on relevance to surgical technique, indications, complications, and comparative outcomes. Meta-analyses, prospective cohort studies, and guideline-based reviews were prioritized for their clinical rigor and applicability.

Surgical Technique & Device Mechanics

The Linx™ Reflux Management System is implanted laparoscopically using a standardized surgical technique that emphasizes preservation of native anatomy, reproducibility across surgical teams, and minimal invasiveness. The procedure can be summarized as follows:

1. Patient Positioning

a. The procedure typically begins with the patient in a steep reverse Trendelenburg position under general anesthesia.

2. Port Placement and Access

a. Standard five-port laparoscopic configuration is used, with port placement generally mirroring that of a Nissen fundoplication.

3. Esophageal Dissection and Hiatal Reduction

a. Circumferential dissection of the distal esophagus is performed to ensure that the Linx device lies at the level of the gastroesophageal junction.

b. In patients with hiatal hernia >3 cm, many surgeons now routinely perform crural repair prior to device placement to minimize recurrence.

4. Sizing and Device Selection

a. A sizer tool is used to fit the appropriate device dimension (~13–17 beads). The Linx system's customizable sizing has been refined to decrease operative times and improve fit accuracy.

5. Device Placement

a. The magnetic ring is guided posterior to the esophagus and secured with a self-locking clasp. The device is designed to expand during swallowing and contract at rest, providing augmented LES pressure while preserving physiology.

6. Closure and Confirmation

a. Integrity of the crural repair and the absence of obstruction are confirmed intraoperatively via endoscopy or bougie passage. Final port removal and standard closure complete the operation [13,14].

The mechanism of action is based on the dynamic magnetic properties of the device. The individual beads exert circumferential magnetic attraction, providing a constant low-pressure barrier to reflux. During swallowing, the ring transiently expands to allow passage of food and then returns to its resting position to reestablish closure of the LES. This preserves the physiologic capacity for belching and vomiting, a significant advantage over traditional fundoplication, which often restricts these reflexes [15]. The placement technique also avoids full dissection or wrapping of the gastric fundus, thus maintaining the integrity of the native gastroesophageal anatomy.

A critical advantage of the Linx system is its reversibility. In contrast to fundoplication, where anatomic distortion may persist even after takedown, the Linx device can be removed with minimal disruption, and long-term studies have confirmed that esophageal function is preserved following explantation in most cases [11]. Additionally, magnetic resonance imaging (MRI) compatibility has improved with newer iterations of the device. All Linx devices implanted after 2015 are now considered safe for 1.5 Tesla MRI, and in 2022, updated regulatory labeling approved conditional use in 3.0 Tesla scanners under controlled imaging protocols [16].

Surgeons generally report a moderate learning curve associated with the Linx procedure. A recent multicenter cohort study analyzing over 600 Linx implantations between 2019 and 2023 found that operative time and complication rates improved significantly after the first 15–20 procedures, suggesting a predictable and surmountable technical threshold for proficiency [17]. The implementation of standardized protocols—including crural repair in appropriate patients, consistent sizing tools, and intraoperative endoscopic validation—has contributed to the high reproducibility and favorable safety profile observed in both academic and community settings [18].

Indications and Contraindications

Since its initial FDA approval, the Linx™ Reflux Management System has seen progressive expansion in its indications as clinical evidence and surgical experience have accumulated. Originally indicated for adult patients with chronic GERD confirmed by abnormal pH monitoring and who remained symptomatic despite maximal medical therapy, the Linx device was initially reserved for individuals with normal esophageal motility, a body mass index (BMI) less than 35 kg/m², no prior upper abdominal surgery, and a hiatal hernia smaller than 3 cm [19].

Recent prospective registry data have expanded the candidacy criteria for MSA to include patients with larger hiatal hernias. A 2019 multicenter review of 350 patients, stratified by hernia size (none, < 3 cm, ≥ 3 cm, or paraesophageal), found similar rates of symptom satisfaction (92 % in the ≥ 3 cm group vs. 86–88 % in smaller hernia groups), GERD-HRQL improvement, freedom from PPI, and postoperative dysphagia across all cohorts at a mean follow-up of 13.6 months. The need for device explantation was also comparable. While larger hernias were associated with slightly higher hernia recurrence, only 2.9 % required reoperation, and complications remained evenly distributed between groups. These findings support the safety and efficacy of combined hiatal hernia repair and MSA—even in hernias ≥ 3 cm—and challenge the previous exclusion of this population from MSA consideration [20]. Similarly, while morbid obesity (BMI ≥35 kg/m²) remains a relative contraindication due to historically inconsistent outcomes, emerging data suggest that MSA may be considered in selected obese patients following intentional weight loss or in conjunction with metabolic interventions [21,22].

New use cases have also emerged in non-classic GERD populations, including those with significant extra-esophageal symptoms. Studies

have shown that MSA can reduce chronic cough, laryngitis, and asthma-like symptoms associated with laryngopharyngeal reflux (LPR), particularly in patients who are refractory to PPI therapy and have objective pH-confirmed reflux [23]. Moreover, MSA has been successfully employed in post-bariatric and post-esophagectomy settings, although such cases still require individualized consideration given the altered anatomy [21,22].

While the spectrum of candidates for Linx implantation has widened, contraindications still exist. Patients with severe esophageal dysmotility, particularly those with absent peristalsis on high-resolution manometry, remain poor candidates due to the risk of exacerbating dysphagia [23]. Additionally, although Barrett's esophagus was once an exclusion criterion, updated consensus now suggests that patients with short-segment Barrett's esophagus without dysplasia may be safely treated with MSA when other parameters are favorable [24].

Caution is still warranted in patients with allergies to device materials such as titanium, nickel, or ferromagnetic alloys. Furthermore, MRI safety remains a practical consideration. While devices implanted after 2015 are MRI-compatible up to 1.5 Tesla, newer guidelines released in 2022 permit scanning at 3.0 Tesla under defined protocols. Nonetheless, this limitation may preclude Linx in patients who require high-resolution or frequent MRI imaging, such as those with neurologic or oncologic comorbidities [25].

Finally, individuals with prior upper gastrointestinal surgeries, such as gastric bypass or extensive foregut resections, may face anatomical barriers to device placement, though reports of successful off-label use are growing in carefully selected cases [21,22]. As such, current best practice is to tailor candidacy decisions based on a combination of objective reflux burden, esophageal function testing, and individualized risk-benefit discussions.

Complications

The safety profile of MSA with the Linx™ Reflux Management System has become increasingly well-characterized over the past five years, with long-term data now available from multicenter registries, institutional series, and post-marketing surveillance databases. Among the most common postoperative complaints is dysphagia, typically transient and mild. The majority of patients experience difficulty swallowing solids during the first few weeks following device implantation, attributed to the temporary inflammatory response and device adaptation phase. Most cases resolve within 90 days with conservative management, including dietary modification and reassurance [26]. For patients with persistent dysphagia beyond 6–8 weeks, endoscopic dilation is effective in the majority of cases and is required in roughly 5–10% of implantations [27].

A 2021 meta-analysis including over 4,000 MSA patients reported that persistent dysphagia occurred in approximately 6.8% of patients at one year, while the need for device explantation due to refractory symptoms was around 3.3% [28]. Notably, explantation is typically performed laparoscopically and can often be followed by a conversion to fundoplication or a return to medical management, depending on symptom recurrence. Importantly, esophageal function is generally preserved after device removal, highlighting the reversibility of MSA [11].

Another important but rare complication is esophageal erosion, defined as transmural penetration of the device into the esophageal lumen. Although erosion was a primary concern during early adoption, recent prospective registries and safety reviews show an erosion rate of <0.1% with modern implantation protocols [29]. When erosion does occur, it is often identified early during routine surveillance or due to progressive dysphagia and can be managed with endoscopic or laparoscopic device removal. Long-term sequelae, including esophageal perforation or stricture, are exceedingly rare with early intervention [30].

Other less common but documented adverse events include gas-related symptoms (such as bloating and flatulence), chest discomfort, and nausea in the early postoperative period. In comparison to Nissen fundoplication, Linx recipients report significantly lower rates of gas-bloat syndrome, with fewer restrictions on the ability to belch or vomit [31]. Postoperative pain is generally limited and resolves within 1–2 weeks. Serious complications such as infection, device migration, or mechanical failure have been infrequently reported in long-term outcome studies, and large registry-based analyses continue to confirm the absence of systemic complications related to the magnetic components [32].

Long-term durability of the device is another crucial consideration. A 2023 five-year follow-up study found a device survival rate exceeding 95%, with minimal need for reoperation when appropriate surgical technique and patient selection criteria were followed . Taken together, these data suggest that while complications such as dysphagia and rare erosions can occur, MSA offers a safe and reversible profile when compared with more anatomically disruptive antireflux procedures.

LINX Outcomes in Comparison to Nissen Fundoplication

As the clinical use of MSA has expanded, numerous studies have evaluated how the Linx™ Reflux Management System compares to the traditional LNF in terms of efficacy, safety, patient satisfaction, and postoperative functionality. The growing body of literature from the last five years has shown that both procedures provide durable symptom control in patients with GERD, but differ significantly in complication profiles and quality-of-life metrics.

Multiple prospective cohort studies and meta-analyses now support the conclusion that symptom resolution rates between MSA and fundoplication are equivalent. A 2020 systematic review by Skubleny et al. found that both procedures achieved comparable reductions in GERD-Health Related Quality of Life (GERD-HRQL) scores at one and three years, with symptom improvement exceeding 80% in both groups [33,34]. Similar findings were confirmed in the C-SAFE registry, a multicenter prospective study that tracked over 1,000 patients across both interventions. At 5-year follow-up, both groups showed sustained improvement in reflux symptoms, with no statistically significant difference in objective pH normalization rates [18].

Where the two procedures diverge more meaningfully is in patient-reported outcomes related to gastrointestinal function. Patients undergoing MSA consistently report significantly lower rates of gas-bloat syndrome, and a preserved ability to belch and vomit. In a matched-pair analysis published in 2021, Aiolfi et al. demonstrated that while both groups saw major reductions in regurgitation and heartburn, 89% of MSA patients retained the ability to vomit, compared to only 41% in the fundoplication cohort. Similarly, postoperative bloating was reported in 10% of MSA patients versus 32% of those undergoing fundoplication [35].

Rates of PPI discontinuation are also favorable in both groups, though MSA patients may be slightly more likely to resume PPI use in the long term. A 2022 observational study found that at 3 years, 82% of MSA patients remained off daily PPIs compared to 87% in the fundoplication group, though this difference was not statistically significant when stratified by severity of baseline reflux [36]. Importantly, patient satisfaction remains high in both groups, but MSA recipients more frequently reported that they would choose the same procedure again, largely due to preservation of natural function and shorter recovery time [37].

Reoperation and device-related complications differ by approach. While MSA carries a small but measurable risk of device-related issues such as dysphagia and rare erosion, fundoplication is associated with a higher rate of revision surgeries due to wrap migration or breakdown. In comparative data from a 2023 surgical outcomes registry, reoperation rates at 5 years were 4.5% for MSA and 6.8% for fundoplication, with the latter group more likely to require redo fundoplication for symptom recurrence [38].

From a cost-effectiveness standpoint, emerging analyses suggest that while MSA may be more expensive upfront due to device costs, it results in fewer long-term readmissions and less need for anti-reflux medications, rendering it cost-neutral or even superior to fundoplication over a 5-year period [9].

Overall, current evidence supports MSA as a clinically equivalent alternative to Nissen fundoplication for appropriately selected patients with GERD, particularly when preserving physiological esophageal function is a priority. In addition to similar reflux control, the Linx device offers lower risk of postoperative bloating, improved ability to belch and vomit, and a high rate of patient satisfaction.

Conclusion

GERD remains a significant global health challenge, with rising incidence and persistent unmet needs among patients who fail or cannot tolerate long-term pharmacologic therapy. PPIs are the cornerstone of initial treatment, but their limitations—both in efficacy and long-term safety—have renewed interest in procedural interventions. For decades, Nissen fundoplication has been the gold standard surgical approach, providing durable reflux control but often at the cost of altered gastric anatomy, bloating, and impaired physiologic function.

The Linx™ Reflux Management System, utilizing MSA, has emerged as a viable, anatomically conservative alternative. Studies confirm that MSA offers symptom control comparable to fundoplication while preserving esophageal function and allowing normal physiological processes such as belching and vomiting. Advances in standardized sizing and concurrent hiatal hernia repair have improved implantation outcomes, with long-term data showing device survival rates exceeding 95% and low reoperation frequencies in well-selected patients.

While MSA carries some risks—most notably transient dysphagia and rare cases of device erosion—its overall complication profile is favorable and typically self-limited. Further refinements in MRI compatibility, expanded indications for larger hiatal hernias and Barrett's esophagus, and emerging applications in post-bariatric and extra-esophageal reflux symptoms reinforce its clinical utility.

Given current evidence, Linx should be considered a first-line surgical option for appropriate GERD patients, not simply an alternative for those declining fundoplication. As indications broaden and experience accumulates, MSA is poised to become a standard tool in the surgical treatment of reflux.

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